INTRODUCING PRODUCTION INNOVATION INTO AN ORGANIZATION: STRUCTURED METHODS FOR PRODUCING COMPUTER SOFTWARE

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Introducing Production Innovation Into an Organization: Structured Methods for Producing Computer Software[1]

by

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Introduction

Introducing a significant process innovation into an organization could be likened to guiding a group of hikers through an unfriendly jungle. Someone has to lead; there has to be some level of agreement that the destination is worth reaching; all sorts of pitfalls must be avoided enroute, and the success of the venture is judged not only by whether the party members reach their goal, but also by the state of their health when they get there.

Just as the hike leader may decide upon the ultimate destination (perhaps in consultation with the hikers), so managers in an organization usually bear primary responsibility for deciding upon the innovation in production methods which will best serve the strategic interests of the organization. Thus, in a narrow sense, managers are the "adopters" of new procedures. However, just as the hypothetical hike leader needs the cooperation of the hikers to traverse the jungle, (unless it is a forced march), so managers require support from the production workers, the users of new production methodologies. To continue the metaphor, the hikers have to 1) agree on the nature and worth of the destination (the potential value of the proposed innovation) and 2) agree to the chosen path (the implementation plan).

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[1] The research reported herein was supported by a grant from the Center for Information Systems Research at the Massachusetts Institute of Technology. The author is very grateful to personnel in the unnamed corporation who saw the utility in asking some tough managerial questions and who provided the research sites. The research team included Walter Popper, Donald McErlean and Jennifer Bertan, all of whom provided invaluable assistance.

Change can be (and frequently is) mandated, of course. However, unless the organization members who are impacted "buy in" to the decision, they may at best underutilize the new methods and at worst, sabotage the innovation (see Keen, 1978; Dowling, 1979). Therefore, before a change in production methods can be successfully implemented, literally hundreds of employees must make an individual positive assessment of that innovation and "adopt" it.

This paper focuses on the adoption decision of these innovation users, rather than on that of the original management decision-maker. In the particular organization studied, the innovation users have more immediate contact with the clients who receive the end products made with the new production methods than do either the managers who made the innovation decision or the methodology designers.

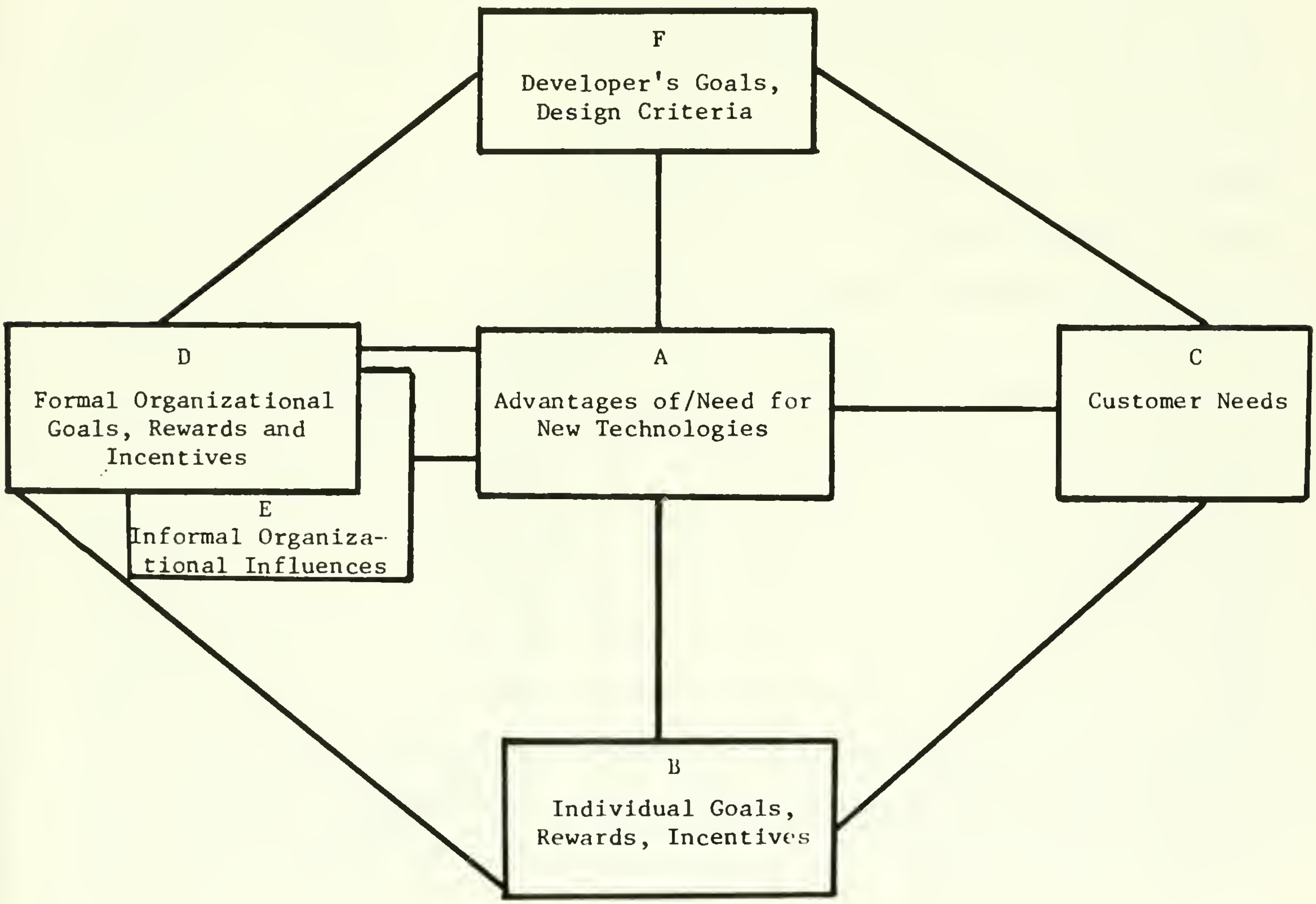
Assessment and acceptance of the innovation by these users is important, therefore, not only because it is they who ultimately hold the power to make the innovation succeed or fail, but because they mediate acceptance by customers of the end products manufactured by the new methods. As Figure 1 implies, the innovation users have not one but three sets of criteria to satisfy when assessing the value of new production methods: their own, their manager's and (in the case reported herein) their customer's. They are people in the middle, subject to pressures from both upstream (management) and downstream (customers, i.e., the market for the product being manufactured by the innovative methods). These innovation users, (production workers) are unlikely to accept a process innovation unless it enhances their ability to produce a superior product and thus to please both managers and customers.

Figure 1

Communication About the Process Innovation

Figure 2

Lines of Potential Interdependence in the Diffusion of Technological Innovations



The Model

Figure 2 presents in diagrammatic form a general framework which the author finds useful in studying the introduction of technological change into a firm. Each of the linkages pictured in Figure 1 is important in determining the success of a production innovation. The major assumption underlying the diagram and the analysis which it engenders, is that use of a process innovation (i.e., the successful implementation of a managerial decision to innovate in production processes) depends on the degree to which each set of variables characterized by boxes A through F is congruent with each other set. The importance of some of these relationships has been well established in the marketing or the diffusion of innovations literature. Other relationships have been slighted in the traditional research and need to be tested empirically. The study described in this paper covers most of the pictured relationships, albeit to varying degrees. Before that study is described, however, a very brief review is provided of some of the major generalizations which can be made about the relationships pictured in Figure 2, based on academic research.

Relationship A-B, between the advantages of and need for, a technological innovation and the personal goals and rewards of the adopting individual has been well explored in the literature on marketing and on the diffusion of innovations. Obviously, the new product or process to be introduced should have a clear advantage for prospective users over whatever is to be supplanted. Furthermore, the less complex the innovation and the more compatible it is with the potential adopter's values, the more likely the new product or process is to succeed (Rogers, 1982). In other words, the more congruence existing between the attributes offered by the work innovation and the set of personal values, skills and job-related satisfactions possessed by the individual, the more attractive the technology.

Linkage A-C between the innovation advantages and the needs of clients is likewise important. The customers, or end beneficiaries of a process innovation may be tertiary, and unwitting, adopters. That is, they may never directly evaluate the technology. They may not even be aware that a new process has been introduced into the construction of the end product they receive (see Leonard-Barton, 1983a). However, the production process may significantly impact the nature of the product they receive. Workers in the production process have to be aware of the extent to which the new technologies help them produce a product which satisfies customer needs. Literature on new product development supports the perception that innovative processes need to satisfy market requirements (the market, in this case, being the customer receiving the end product). Products pulled into existence by market needs succeed more than those propelled into the world by the sheer momentum of technological advance (Marquis, 1969; Freeman et al. 1972).[1]

Therefore it is incumbent upon the innovation developers to consider both innovation user and customer needs in the design of the new technologies. The designer's criteria for success must match those of both primary innovation users (F-B) and ultimate product recipients (F-C). Moreover, those design criteria need to fit the formal organizational goals and reward systems (F-D). In other words, the innovation developers need to be integrated enough into the organization to understand how the technologies they are designing fit current organizational priorities, or else be prepared to revolutionize those goals and priorities in the course of introducing the new technology.

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[1] In a critique of this literature, Mowrey and Rosenberg point out that authors have frequently confused potential market need for market demand in their methodologies and have consequently overstated the case for market pull. However, these critics tend to bias their analysis in the opposite direction by defining market pull in the narrowest possible sense. Whether the market need precedes or follows technological innovation, there must be a match if the innovation is to thrive.

Moreover, once the innovation designs are embodied in actual technologies, the benefits to be derived from using the innovation need to match the organizational goals and reward system (D-A), else the potential users will have little incentive to fully implement the management adoption decision. Thus, relationship F-D expresses the technology developers' understanding of the organization and D-A, the extent to which that understanding is successfully translated into the physical hardware or software of the new production system. The importance of these relationships, once again, is suggested by marketing principles. Although the "market" in this case is internal to the organization, the innovation must fit market needs in principle and in fact in order to succeed.

Informal organizational influences (Box E) include the power of communication networks or of corporate "culture" to circumvent or support organizational goals (Link E-D) and the importance of "shadow" organizational hierarchies, i.e., informally determined roles, in the acceptance or rejection of new technologies (relationship E-A). For instance, a set of informally recognized but powerful expectations which run counter to the formal organizational reward system are unlikely to be fulfilled.[2] When informal influences 1) reinforce organizational goals or 2) impact perceptions of the value of a technology, the informal structures importantly affect the diffusion of an innovation. An example of the former is the case of a dynamic leader who inspires people to commit to unusual work loads or who "champions" an entrepreneurial venture (Maidique, 1980). Instances of the latter include cases in which favorable information supporting the need for or advantages of, an innovation foster its diffusion while negative sources of information serve as focal points for the rejection of a new product or process.

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[2] Steven Kerr is his perceptive article about "The Folly of Rewarding A While Hoping for B" notes a number of such inconsistencies, such as the policy of universities to expect excellent teaching but to formally reward only research.

Market rather than organizational settings provide most of the research evidence on the relationship E-A, both positive (e.g., Arndt, 1967; Whyte, 1954, or Leonard-Barton, 1983, on the innovation-encouraging effects of positive word-of-mouth and opinion leadership) and negative (e.g., Midgley, 1977; Technical Assistance Research Programs, 1981; Richins, 1983, and Leonard-Barton, 1983 on the inhibiting effects of negative word-of-mouth and negative opinion leaders).

Moreover, the literature on organizational behavior has recently begun to emphasize the overall importance of goal congruence among organizational members and elements. (See, for instance, Nadler and Tushman, 1980.)

The study setting described below offered an opportunity to examine most of the relationships pictured in Figure 2 and hypothesized, on the basis of previous research, to be of importance in the diffusion of a process innovation. As noted before, the study focuses on the individual user-adopter as the unit of analysis; therefore, all the relationships are examined through the screen of those adopters' perceptions, not as a set of independently measured relationships. However, perceptions, not reality (presuming there is such a thing as an objectively determined reality) govern people's actions. What this study attempts to accomplish is the examination of numerous, very different influences on the attitudes and use by organizational members of a production innovation.

<u>Research Setting</u>

The opportunity to conduct the study arose because a major U.S. -based firm wished to identify major barriers slowing the diffusion of several process innovations in which this corporation (hereafter referred to as VLC) has invested much time, money and staff support. The innovations are methodologies designed to provide a structured, standardized approach to the construction of computer software.

The motivation behind the innovation was a need for greater productivity; VLC, like many of its counterparts, expends tremendous resources on the development, enhancement and maintenance of computer software to support their internal operations, e.g., administration, finance, engineering, production. As is now generally recognized, software, not hardware, sets the limits to use of computers in business.[3] The construction of software has traditionally been an individual craft rather than a standardized production procedure, with the result that it is difficult for one person to enhance or maintain another's highly individualistic piece of work.[4] The assumption behind the development of the engineering approach to software construction is that standardization will lead to greater efficiency by enabling programmer/analysts to "hand-off" programs or even modules within programs, to each other, since everyone will use the same approach.[5] Acting on this assumption, VLC has set out guidelines for their thousands of programmer/ analysts worldwide which specifically require the use of the methodologies for given system development tasks.

However, there are no actual sanctions for not using the methodologies, and in fact, little formal attempt to check on whether they are used or not. Therefore, although the corporate management has clearly signaled its desire that the methodologies be used, in practice, analyst groups have considerable freedom to choose.

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[3] Computer software costs usually contribute at least 65-75% of the total system cost (Datapro, 1976).

[4] Organizations can expect to spend 50% or more of their annual data processing budgets on maintaining previously written programs (Brooks, 1975).

[5] It should be noted at the outset that VLC has not even tried and other corporations using similar approaches have not been able to prove, that in fact these methodologies enhance productivity. The applications, tools, and methodologies are changing so rapidly that only a high-cost, controlled experiment could establish the value of the structured approach for certain.

The Innovations

Five innovations were studied, but for the purposes of this paper, discussion is confined to one of the two most prevalent and recently introduced methodologies: Structured Systems Analysis (hereafter SSA). It was developed by a corporate group, at corporate headquarters, for dissemination to and use by analysts in multiple sites around the world. SSA is applied by analysts to the first stages of building a system. Following this methodology (which is set out in books), the programmer/analysts constructs a diagrammatic flow model of the client's business, and of information flows through that business (e.g., customer orders and service or factory production lines). SSA, its developers feel, provides an effective communication mechanism (diagrams) for identifying client needs, objectives, and limitations. This early design phase is extremely critical since errors in requirements definition are highly expensive. The notation used is consistent with the other, downstream methodologies used to guide the production of simple, maintainable code. The common "language" enforced by use of SSA not only facilitates the hand-off from system designers to programmers, who write the actual code, but aids in later revisions of the system.

Research Sample and Methods

The research was conducted in three phases, moving from unstructured interviews with the innovation developers and potential or actual users at corporate headquarters (N=20), through the testing on a group of about 25 analysts at corporate headquarters of first semistructured and then highly structured questionnaires, to a final three-site survey. The three sites were: 1) Corporate Headquarters, (N=28); 2) a U.S.-based affiliate, (N=56); 3) an international affiliate, (N=61). Although analysis has revealed a few site-specific differences among the populations studied, measures of most of the key variables seem to be site-independent. Therefore, the analysis in this paper is based on the personal

interviews with all 145 programmer/analysts, including some supervisors and analysts whose primary responsibilities are project management rather than code generation. Table 1 lists the operational variables implied by the model presented in Figure 2.

The use or nonuse of the particular set of innovations studied here is extremely difficult to measure, for a number of reasons. First, each methodology is particularly applicable to a certain set of tasks; assignments among analysts differ. An analyst who is concerned mostly with the maintenance of software developed years ago, for instance, would have little occasion to use SSA, while an analyst whose expertise lies principally in scoping out large systems might have the chance to use SSA literally every day. Therefore, task assignment determines opportunity to use the methodologies.

Furthermore, despite the guidelines, there is not universal agreement as to when the methodologies are applicable to a given task. Naturally, the methods developers see a much wider range of possible applications than do the analysts. To ensure that the dependent variable is sensitive to these nuances, usage is measured as a function of task assignment. Usage on each methodology is measured only for those analysts who have had some occasion to perform the relevant tasks. In addition, each respondent was asked to state what alternatives were employed in completing the tasks, so that it is possible to determine whether a response of "not applicable" refers to lack of opportunity for use or a judgment about the relevance of the methodology. Furthermore, for some variables, responses only make sense if the respondents have in fact, some experiential (rather than merely attitudinal) basis for making a judgment, i.e., they have received formal or informal training in the methodology.

Table 1

Variables Influencing the Diffusion of Technological Innovations Within Organizations

A	B	C
The New Technologies	**Individual Goals, Rewards, Incentives**	**Customer Needs**
- Attributes of the technologies (advantages/ disadvantages)	- Demographics (age, education, etc). - Technical skills - Personal goals (managerial or technical career) - Attitudes towards this generic type of technology - Attitudes towards these specific technologies	- Desired product characteristics - Constraints on technology use (budgets, etc.)

D	E	F
Formal Organizational Goals, Rewards, Incentives	**Informal Organizational Influences**	**Developers' Goals, Design Criteria**
- Values placed on technology - Supervisor's desires - Promotion criteria - Guidelines for use of technology	- Presence/absence of technology advocates	- Desired innovation characteristics - Communication with innovation users.

If the study had been a technical and "objective" or "expert" evaluation of the methodologies, the focus would have been the upper half of the diamond in Figure 2 (the relationship of F to D, A, and C), i.e., the extent to which the innovation developers 1) understood the needs of both organizational users and customers and 2) embodied that understanding in a technically adequate innovation.

However, the study actually focuses on the bottom half of the diamond. That is, the study explores users' perceptions of 1) how well the technologies (as they stand) match organizational reward systems and client needs, (the relationship of A to B, C, and D) and 2) how consistent those rewards and needs are with those of individual analysts/users the relationship of B to C and D.

Findings

The major assumption underlying the development of these technologies is that their use will result in a superior product, namely more accurate and easily maintained computer software. Even assuming that the new methodologies in fact deliver those technical advantages, a more basic question remains to be answered: Are those advantages, or innovation characteristics, ones which the analysts believe to be rewarded by the organization and desired by clients? In short, do the analysts/users have good reason to want more accurate, easily maintained software?

To answer this question, analysts were asked to rank the top three out of ten possible attributes[6] which might characterize any given systems development project, according to what they themselves regarded as the three critical characteristics, what they felt their clients would rank most highly, then according to what their supervisors and what top management would consider to constitute a job well done. As Table 2 shows, three characteristics were regarded by analysts as generally important to everyone: 1) completed on time: 2) designed

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[6] The ten were derived from the in-depth unstructured interviews in Phase One as described above.

to user specification; and 3) providing accurate solution. However, when weighted rankings for the four groups are compared, all are significantly different except for the analysts' perception of their own ranking compared with their clients' on two characteristics: 1) completed on time; and 2) designed to user specifications. On these two attributes, the analysts felt their own opinion coincided with their clients'. Therefore, linkage C-B is a congruent one. The most highly significant differences occurred between the analysts and clients on the one hand and supervisors and top management on the other. From the analysts' perspective, management cares almost exclusively about having projects brought in on time and, of paramount importance, on budget.

Evidently, then, analysts feel some tension in relationship B-D in Figure 2: the contrast between their own personal goals for a project (which they perceive as being closer to their clients' than to their supervisor's or to top management's) and the project goals of management. A job well done in their eyes does not necessarily constitute one well done by management standards. Their promotion and performance evaluations depend of course on meeting management goals.

What about relationship B-A-D, the use of the technologies to accomplish these management-set goals and objectives? It is interesting to note in this context what analysts considered to be the major advantages and disadvantages of the new methodology. As Table 3 shows, the major advantages of SSA are ones which would aid an analyst in providing a more accurate solution and in designing to user specifications. At first glance, there is no apparent barrier to the use of the new methodology. However, as Table 3 also indicates, the principal disadvantages of the use of SSA (aside from a lack of familiarity with it and therefore the costly necessity of learning something new) is that it is too time-consuming to use and too expensive for the budget.[7] Since, as noted above, analysts

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[7] Since analysts charge their time to a given project, these two are related. However, they are not identical.

TABLE 2.

Analysts' Perceptions of Product Characteristics
Most Valued by Them, by Their Clients, by Their Supervisors, and by Top Management (N = 145)

Product Characteristics	Analysts			Clients			Supervisors			Top Management		
	Number[a]	Weighted Average[b]	Ranking[c]	Number[a]	Weighted Average[b]	Ranking[c]	Number[a]	Weighted Average[b]	Ranking[c]	Number[a]	Weighted Average[b]	Ranking[c]
Completed on time	4	5.2[d]	3	20	4.6[d]	4	48	2.9	1	23	3.6	2
Within budget	4	5.8	6	12	4.8	5	46	2.8	2	76	2.0	1
Designed to user specifications	50	3.7[d]	2	56	3.3[d]	1	21	4.9	3	15	5.2	3
Accurate solution	58	3.8	1	29	4.5	2	19	5.4	4	13	5.6	4
Good communication with user	7	5.8	7	10	6.0	6	0	6.4		4	6.2	6
Clearly documented	0	6.4		0	6.6	7	2	6.2	2	1	6.7	
Easily enhanced	0	6.7		1	6.8		0	6.9	C	0	6.9	
Easily maintained	5	5.6	5	0	6.8		2	6.3	7	2	6.3	7
Meets organizational guidelines, standards	0	6.6		0	7.0		4	6.3	6	8	5.6	5
Easily run by user	10	5.5	4	17	4.5	3	2	6.8		1	6.8	
Other (written in)	4	6.8		1	6.9		0	6.9		1	6.9	
Missing Data	1			1			1			1		
Total	145			145			145			145		

[a]Number of analysta who ranked this product characteristic as most important to this group of individuals (e.g., Clients, Supervisors) in evaluating the product.

[b]This figure waa obtained by weighting responses according to their ranking in importance by each respondent (the most important characteristic was weighted by 1, the second by 2, the third by 3, and "not selected" by 7), then totalling and averaging the weighted responses. The potential range is therefore 1-7. The smaller the number the more important the characteristic.

[c]Based on average weighted rankings.

[d]Weighted rankinga not significantly different between analysts and clients at the $p < .01$ level.
All other mean rankings are significantly different.

TABLE 3.

Principal Advantages and Disadvantages of SSA, According to Analysts (N = 145)

SSA Advantages	Weighted Rankings[a]	SSA Disadvantages	Weighted Rankings[a]
1. Helps me understand client's business	3.7	1. Unfamiliar	2.2
2. Is a structured approach	4.7	2. Time-consuming to use	3.0
3. Improves requirement definition	4.9	3. Too expensive for client (time and budget)	5.6
4. Provides improved communication	5.6	4. Not oriented to my application	5.8
		5. Not useful for maintenance	5.9

[a]Respondents were asked to select and record in ranked order, the three most important advantages and disadvantages of each methodology. Responses were weighted by their rank order (e.g., third ranked = 3); reponses not selected were arbitrarily assigned the average ranking of 8 for advantages and 7 for disavantages, on the assumption that responses not selected, if ranked, would be randomly distributed among all possible remaining rankings (i.e., 4 to 12 for advantages, 4 to 11 for disadvantages). The rankings were then aggregated and averaged. The smaller the number shown in the table, the higher the rank, or average, given to this response.

are keenly aware of time and budget as the primary criteria for success in the eyes of supervisors and management, the fact that SSA requires an up-front investment by the client and the analyst in analyzing the business in the structured fashion would seem to constitute a serious impediment to use.

These findings lead logically to the question: If an analyst believes that the use of SSA is costly in terms of time and of budget and he/she also believes that there is pressure from clients or management to be on time and within budget, is that analyst less likely to use SSA?

The answer, as Table 4 shows, is not clear from the statistics alone. There is no evidence that the fact SSA requires time is, in and of itself, a barrier to use. A slight positive relationship exists between 1) the variable, awareness of conflict between product attributes and management goals, and 2) usage, but the chi square is not significant. In Table 4, the variable measuring conflict in goals (i.e., SSA takes time and being on time is a top goal) combines responses referring to the analyst, the client, the supervisor and top management. If each category is singled out for separate analysis, there is a strong positive relationship between use of SSA and the analysts' belief that the client wants the project done on time but that SSA is time-consuming (Chi square 10.25 with 2 D.F.; significance level, p. - .006).

This finding initially seems counter-intuitive. Why would SSA users be more likely than non-users to admit that SSA is time-consuming and that their clients value time? We found the explanation by going back to the lengthy initial interviews held with users.

SSA users are very conscious that by using these structured methodologies, they are investing their clients' and their own time now, so that their clients can reap the benefits later of less time spent on maintenance and revision. As one user expressed it, "I have to educate my clients about the pay-offs down the

TABLE 4.

Relationship Between Use of SSA and Analysts' Perceptions that SSA is Time-Consuming But Time is Important

Use of SSA	No Perceived Conflict[a]	is Time-Consuming and Time is Important[b]	
No Use	25 (49.0)	20 (33.3)	45
Some Use	14 (27.5)	21 (35.0)	35
Heavy Use	12 (23.5)	19 (31.7)	31
	51 (100.0)	60 (100.0)	111

Chi Square = 2.83, with 2 D.F. Significance level, p. = .24.

[a]These respondents do not satisfy both conditions, i.e., do not believe SSA is time-consuming and/or did not believe time is important in evaluation of a job.

[b]These respondents both believe SSA is very time-consuming and that time is very important (to themselves, their clients, their supervisors, top management or to more than one of these groups).

road." In short, SSA users tend to be very conscious of the life-cycle costs of the innovation while, as noted below, non-users see only the front-end expenses.

As Table 5 indicates, the more that an analyst feels cost is a disadvantage of SSA and also believes budget is a primary concern, the less likely that analyst is to use SSA heavily. Table 5 shows that the measure combining all responses (for the analyst, client, supervisor and top management) is negatively related to usage (significant at the p. = .07 level). However once again, the relationship is considerably stronger if the client is the source of pressure to stay within the budget (Chi square = 6.79, with 2 D.F.; significance level, p. = .03).

In summary, there are some important perceived conflicts in relationship B-A-D and B-A-C. The methodologies cost time at the front-end of the project and therefore more money to the clients. Those analysts who can rationalize the front-end investment to their clients by explaining the deferred benefits, are using SSA. Those analysts who either disbelieve that those long-term benefits offset immediate costs, or cannot persuade their customers of the life-cycle cost benefits, do not use SSA. The more client pressure to stay within budget, the less the analysts are inclined to use the innovation.

If clients indirectly influence the analysts' decision about use of SSA through setting priorities, they could presumably influence that decision quite directly through positive or negative evaluations of the innovation itself (relationship C-A).

Like most professionals possessed of specialized knowledge, system development programmer/analysts know their clients are unable to judge the merits of a new process innovation (except as it is reflected in final product), and clients are often totally unaware that innovations have been introduced into the construction of the product they receive (Leonard-Barton, 1983). In our survey, about half of the respondents felt it unimportant that a client know how a program works, "as

TABLE 5.

Relationship Between Use of SSA and Analysts' Perceptions that SSA is Costly But Staying Within Budget is Important

Use of SSA	No Perceived Conflict[a]	SSA is Costly and Staying Within Budget is very Important[b]	
No Use	34 (43.0)	11 (46.7)	45
Some Use	20 (25.3)	15 (46.9)	35
Heavy Use	25 (31.6)	6 (18.8)	31
	79 (100.0)	32 (100.0)	111

Chi Square = 5.13, with 2 D.F. Significance level, p. = .07.

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[a]These respondents do not satisfy both conditions, i.e., do not believe SSA is costly and/or do not believe staying within the budget is a primary concern.

[b]These respondents both believe SSA is very costly and that staying within budget is very important (to themselves, their clients, their supervisors, top management, or to more than one of these groups).

long as it does the job"; 60 percent said that client users "don't really want to know how a program works," and less than 20 percent felt that clients appreciated the work done more if and when the new methodologies were used to produce it. In short, many respondents doubted that a direct assessment by clients of the need for and advantages of the new methodologies (linkage C-A) was important. However, those respondents who scored above the average on a three-item scale measuring perceptions about the extent of client interest in the methodology (constructed from the items cited above; alpha = .58) were in fact, much more likely to use SSA than were those who fell below the mean on the scale (see Table 6). Of course, this relationship could represent users' post-adoption rationalization about reasons for use rather than a perceived need which was driving adoption. Either way, those individuals who perceived congruence between client needs and the advantages of the innovation were more likely to use SSA than those analysts who did not.

The analysts' own attitudes towards the innovation (relationship B-A) were also measured, as one kind of incentive to use SSA. Differences of opinion exist about the wisdom and feasibility of moving software production from an art form into a standardized, engineering process, but one would expect that SSA users have a more favorable opinion towards the structured approach in general and towards this structured method in particular, than do non-users.[8] A five-item scale (alpha = .58) set up to measure attitudes towards structured systems development as a concept confirms this expectation by relating positively to usage (Chi square = 7.52 with 2 D.F.; significance level p. = .02). Moreover, as expected, positive attitudes towards this particular project to develop structured methodol-

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[8] Of course, no causality can be assigned here, since the research was conducted at one point in time well after the introduction of the innovation. It is plausible that users rationalize their adoption and use of the methodologies by assuming positive attitudes towards structured methodologies in general. Indeed, the attributionists among psychologists would explain the relationship this way (Bem, 1967), while learning theorists would posit favorable attitudes as predecessors to trial and adoption.

TABLE 6.

Relationship Between Respondents' Perceptions
of Client Desires and Usage of SSA

Respondent Scores on Scale Measuring Client
Awareness of and Desire For Structured Techniques

Use of SSA	Below Average	Above Average	
No Use	16 (69.6)	7 (30.4)	23
Some Use	14 (46.7)	16 (53.3)	30
Heavy Use	10 (33.3)	20 (66.7)	30
	40 (100.0)	43 (100.0)	83 (100.0)

Chi Square = 6.89, with 2 D.F. Significance level p. = .03.

ogies (as measured on a six-item scale; alpha = .60) also relate positively to their use (Chi square = 10.85 with 2 D.F.; significance level p. = .004).

Another set of individual incentives, rewards and goals, which are determined independently from any exposure to the innovation were also measured. An innovation may be perceived as intrinsically rewarding or threatening depending on whether it calls upon or obsoletes a set of valued skills. Education (in this case, computer science background) might therefore be expected to relate to usage. As Table 7A shows, there is more use of SSA among analysts without a computer science background. However, further analysis revealed the reason: the computer scientists among the programmer/analysts are much less likely to have received training in SSA (Chi square = 9.8, with 1 D.F.; significance level p. = .001). Among those analysts who have been trained (Table 7B), the computer scientists and their non-technical colleagues are equally likely to use the innovation,

However, some subtle self-selection may be at work here. Analysts have some freedom (the amount varies according to the skills and experience of the analysts as well as the personality of their supervisors) to decide on their own training and therefore to determine their access to SSA. The implication is that analysts with schooling in computer science feel less necessity to train in and use SSA than do their colleagues with non-computer-related educations.

This finding is further supported by the data displayed in Table 8. Analysts who expect to be engaged principally in technical work in the future are less likely to use SSA now than those aiming at a managerial career. Respondents were asked what kind of job they expected to have five years from now, and what kind of career they intended to pursue. The responses to both questions showed a split between SSA users and non-users, with the future managers being the users. It is not clear to what extent these career goals are impacted by work assignments and other organizational influences.

TABLE 7.

Relationship Between Type of Education and Use of SSA

A.

Usage of SSA[c]	Computer Education[a]	Non-Computer Education[b]	
None	23 (57.5)	12 (21.8)	35
Use[c]	17 (42.5)	43 (78.2)	60
	40 (100.0)	55 (100.0)	95 (100.0)

Corrected Chi Square = 11.18, with 1 D.F. Significance Level, p. = .0008.

B.

Usage of SSA Controlling for Training	Computer Education[a,d]	Non-Computer Education[b,d]	
None	12 (60.0)	28 (59.6)	40
Use[c]	8 (40.0)	19 (40.4)	27
	20 (100.0)	47 (100.0)	67 100.0

Corrected Chi Square = .000, with 1 D.F. Significance Level, p. = 1.00.

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[a]Respondents with a B.S. or M.S. in computer science

[b]Respondents with a B.A. or M.A. in non-computer-related fields.

[c]Includes both light and heavy users.

[d]Excluding respondents who have had no training in SSA.

TABLE 8.

Usage of SSA According to Whether

Analysts Intend to Pursue a Technical

or Managerial Career[a]

Career Path

Use of SSA	Managerial	Technical	
No Use	9 (17.3)	14 (46.7)	23
Some Use	19 (36.5)	11 (36.7)	30
Heavy Use	24 (46.2)	5 (16.7)	
	52 (100.0)	30 (100.0)	82 (100.0)

Chi Square = 10.52, with 2 D.F. Significance level p. = .005.

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[a]Controlling for training; i.e., these data are collected from analysts who have had training in SSA.

There are other, more direct measures of the extent to which the organization encourages the use of SSA (link D-A). Respondent users of SSA scored high on a four-item scale (alpha = .55) set up to measure the analysts' perception of organizational values supporting the use of the new technologies (e.g., that good programming is rewarded and quality of work desired over quantity) (Chi square = 8.97 with 2 D.F.; significance level, p. = .01). However, one individual item in that scale discriminates especially well between users and non-users. If an analyst's supervisor for the past 12 months wanted the analyst to use SSA, he/she was much more likely to do so than fellow analysts without this organizational prod. (See Table 9).

Not only formal encouragement makes a difference, however. Those analysts who report knowing a "real advocate," someone who "really sells" SSA, are more likely to use the methodology than their colleagues who know no such enthusiast; (relationship E-A in Figure 2; see Table 10).

The importance of such informal "innovation champions" was further demonstrated by the fact that, although usage levels did not significantly differ among the three sites studied, attitudes towards the concept of structured methodologies, towards the corporate innovation developers, and towards SSA itself, did. Attitudes at the international affiliate were consistently more positive. Interviews revealed that many analysts at that site were aware they had on their staff a real SSA expert, an individual who was early involved in the development of the innovation, who understands it well and who has championed its use.

Such advocates not only serve as role models and consultants but at least some of them actively persuade people that the extra time involved in using SSA is worth the effort.

TABLE 9.

Effects of Supervisor's Desires on SSA Usage Levels

		Mean Usage[d]	T Value	Significance Level
I.	Group[a] whose Supervisor wanted them to use SSA[b]	2.81	6.03	.000
	Group[a] whose Supervisor did not necessarily want them to use SSA[c]	1.53		

[a]Group determined by respondents' agreement or disagreement with the statement: "My supervisor would have liked me to use SSA."

[b]Defined as responses 4 or 5 on a five-point scale (61 cases) where 1 = Strongly Disagree and 5 = Strongly Agree with the statement in note a above.

[c]Defined as responses 1, 2, or 3 on a five-point scale (70 cases).

[d]Usage of SSA where 1 = Never and 5 = Always.

TABLE 10.

Differences in SSA Usage Levels Between
Groups Knowing or Not Knowing
a Product Advocate[a]

	Mean Usage[b] Level	T Value	Significance Level
I. SSA Structured Systems Analysis			
(a) Group knowing advocate	2.65	5.42	.000
(b) Group not knowing advocate	1.47		

[a]Respondents were asked directly if they knew an advocate for each methodology.

[b]Usage of methodology where 1 = Never and 5 = Always.

Summary and Conclusions

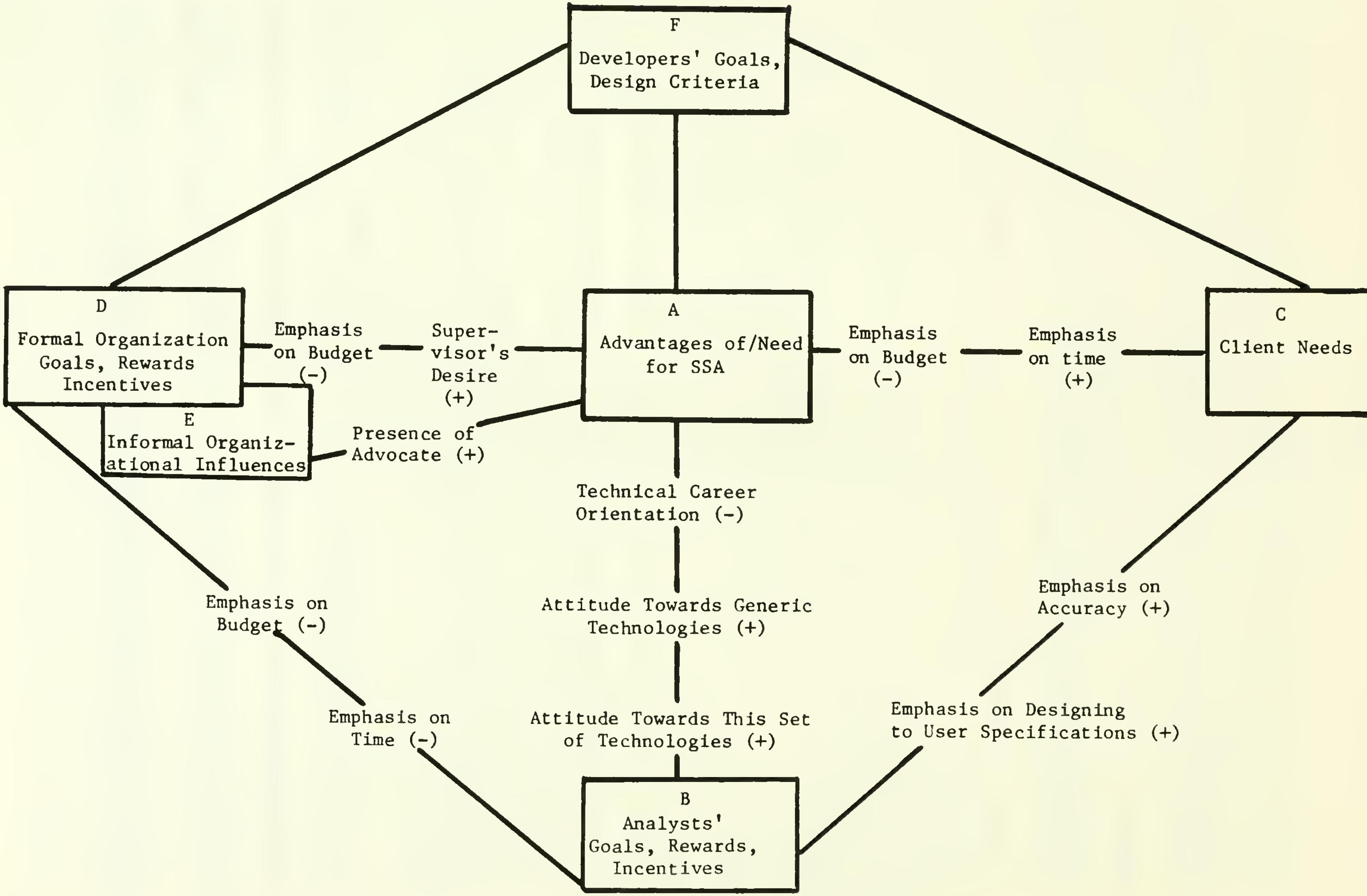
The adoption decision of a manager is not usually in itself enough to ensure the acceptance and use of a new production technology. The organizational workers most directly impacted by the innovation have to decide for themselves that the new methods are advantageous.

That decision is influenced not only by the fairly obvious and oft-discussed relationship between worker skills and attitudes towards the new technology or formal, direct organizational signals (e.g., mandated use) but by indirect and less superficially obvious organizational incentives. To the extent that the innovation users receive consistent signals from all quarters (e.g.,,in criteria for their job promotion, in customer desires, and from supervisors), the innovation will be rapidly accepted. To the extent that there are inconsistencies and conflicts in the system, the users are likely to drag their feet or reject the innovation outright.

In the VLC organization studied here, the formal organizational directive is clear; use SSA. When supervisors in the hierarchy enforce that mandate, analysts tend to obey. However, many programmer/analysts in the study who are the potential innovation users are still not using the new methodology. Figure 3 summarizes the reasons why some analysts do and do not adopt. A key reason for rejecting SSA appears to be the analysts' inability to justify its use on a life-cycle costing basis. That is, if clients do not believe that the long-term benefits to be gained from using SSA justify the required front-end expenses, or if, in the analysts' perceptions, management's primary criterion for a job well done is that it be within budget, then the analysts fear they will be penalized rather than rewarded for using SSA. Several forces can allay this fear. A supervisor who believes in SSA presumably evaluates favorably an analyst who uses it.

Figure 3.

Relationships in the Diffusion of SSA which are Congruent (+) or Conflicting (-)



Similarly, if the analyst has convinced his or her clientele that SSA yields long-term benefits, that satisfied client favorably influences the supervisor's evaluation by positive reports about the analyst's work (or, more accurately, by silence, since no news from clients is good news, according to the survey respondents). A strong advocate of SSA likewise influences analysts to use the innovation despite the problems of the inadequate cost reporting system, probably by providing ammunition with which to convince client or supervisor of its value.

Clearly, VLC could do more to protect their investment in this methodology, by removing the inconsistencies in the system. If the future benefits to be derived from lower maintenance costs of systems constructed with SSA were factored into the project budget and control system, then the analysts would have much more consistent incentives to use the innovation. Informal advocates as well as supervisors could be more directly encouraged. Finally, since the clients are also ultimate beneficiaries of the innovation, they should be openly acknowledged as important influences on the diffusion process. The innovation could be "pulled through" the system by demand from clients, if enough of them came to believe in the long-term benefits. At present most are unaware that the analysts have a choice of methodologies, and therefore that they themselves have any stake in <u>how</u> their software is developed.

As noted at the beginning of this paper, the introduction of a process innovation is a complex process, involving as it does hundreds of individual decisions, but within an organizational context, the influential characteristics of which are not always readily apparent. In this study, we have dealt with the diffusion of a new methodology, after it was already designed (bottom half of Figure 2); a more complete research project would explicitly examine the relationship of the developers to the other organizational actors, during the design of the innovation as well. Further research on the topic is planned to do just that.

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